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Studies on Leaf Burn of Pear Trees

V. Leaf Water Content and Climatic Condition

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It was reported in the previous report that when the water content of detached pear leaves decreased less than 52 percent turning brown appeared in the leaves (IIZUKA et al. 1972 b). And it was described that the leaves of pear cultivars susceptible to leaf burn had a great number of stomata remained open (YAMAMOTO et al. 1973). It is necessary for prevention of leaf burn to investigate weather conditions accelerating leaf transpiration. ISHIZUKA (1965) reported that leaf burn of pear trees developed mostly on days of high air temperature. And KUMASHIRO et al. (1971) found that there were high correlations between development of leaf burn and daily maximum air temperature, daily minimum humidity and daily evaporation.

In this report, a change in meteorological elements before and during the developments of leaf burn, its effect on leaf water content and patterns of symptom of leaf burn in pear leaves were investigated, and these results were reported.

Materials and Methods

Twenty four-year-old 'Bartlett' and 'La France' pear trees grown on the orchard of Faculty of Agriculture, Yamagata University were used. Injured leaves were counted and removed from a secondary scaffold limb every day.

In order to measure a water content of pear leaves, electric capacity of a leaf was measured and was indicated as dielectric constant by the same method as described by IIZUKA (1967). The apparatus for measuring capacity of a leaf is presented in Fig. 1. When based on a ratio of water and dry matter, there is a linear relation between leaf dielectric constant and water content of a pear leaf (Fig. 2 and TAKECHI et al. 1968).

Injured leaves of 'Bartlett' trees were collected from July to September in 1971. As actual leaf burn is similar in appearance to the symptom in a necrosis of a leaf desication, 'Bartlett' shoots were wounded by cutting shoot bases at a depth of two-thirds shoot diameter to develop leaf desiccation. Then the necrosis developed by leaf desiccation were compared with that of actual leaf burn.

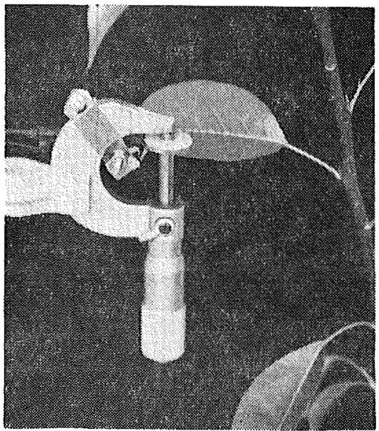
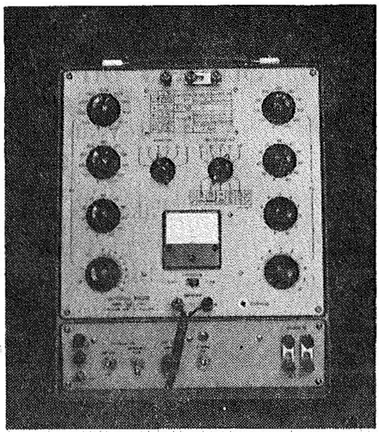

Fig. 1. The apparatus for measuring electric capacity of pear leaves. Right : Bridge, Left : Measurement terminal

Meteorological data were presented from Meteorological Observatory of Faculty of Agriculture at about 50 meters from the orchard.

For measurement of soil water samples were taken from four points in the orchard, and were determined by a dry method. Further soil water was measured with a tensiometer buried at 20 cm depth in the orchard soil.

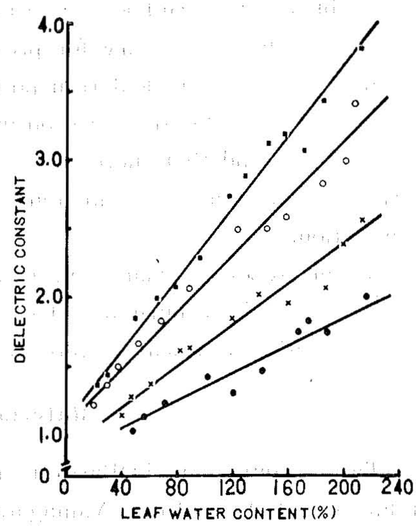

Fig. 2. Relation of dielectric constant and leaf water contents (water weight / dry matter weight X 100) in 4 leaves of 'Bartlett' trees.

Results

1. *Patterns of symptom of leaf burn*

With respect to symptom of leaf burn, it was simply described in the previous report (1972 a), the symptom patterns was so interest that patterns of symptom were described again and in detail.

The patterns of the symtom of leaf burn were classified into six types from location and size of lesion in a leaf as shown in Fig. 3. The six types are as follows :

(1). An entire leaf turns black.

(2). One side of a leaf separated by a midvein turns black.

(3). A patch within a leaf turns black.

(4). A leaf tip and a margin turn black.

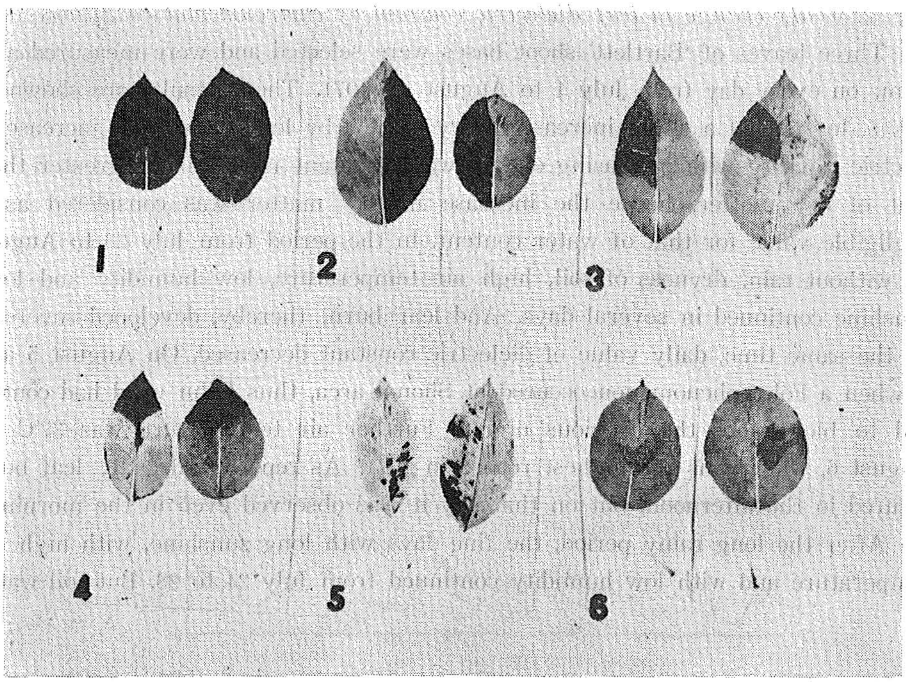

Fig. 3. Patterns of leaf burn symptom in the leaves of 'Bartlett' pear trees.
(1). An entire leaf turns black.
(2). One side of a leaf separated by a midvein turns black.
(3). A patch within a leaf turns black.
(4). A leaf tip and a margin turn black.
(5). Scattered black speckles
(6). Interveinal lesion

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(6). Interveinal lesion

However, there were combinations or transitions of patterns between the six types, and leaf burn of first type was mostly found in the spurs under severely dry weather. Leaf burn of fifth and sixth types seldm developed. The symptom patterns of leaf desiccation by an incised wound at shoot bases were similar in appearance to that of tip and margin types of leaf burn. This symptom appeared after 3 days from the wounded day (Fig. 4.).

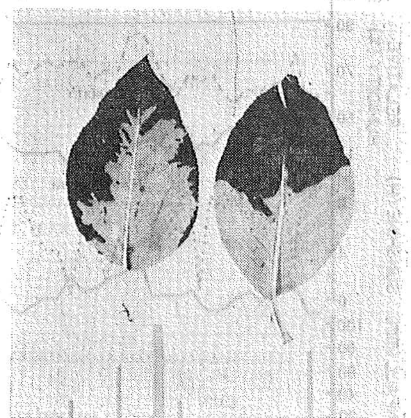

Fig. 4. Necrosis developed in leaves of the shoots wounded at their bases of 'Bartlett' trees.

2. Daily change in leaf dielectric constant by environmental conditions

Three leaves of 'Bartlett' shoot bases were selected and were measured at 2 p. m. on every day from July 1 to August 31, 1971. These results are shown in Fig. 5. In spite of a slight increase in dry matter by leaf growth, an increase in electric capacity with increasing of leaf water content is strikingly greater than that of dry matter, hence the increase in dry matter was considered as a negligible value for that of water content. In the period from July 28 to August 10, without rain, dryness of soil, high air temperature, low humidity and long sunshine continued in several days. And leaf burn, thereby, developed severely. At the same time, daily value of dielectric constant decreased. On August 5 and 6, when a Föhn phenomenon occured at Shonai area, thus Föhn wind had continued to blow since the previous nights. Further air temperature was 37℃ on August 6, which was the highest record in 1971. As reported already, leaf burn occured in the afternoon, but on that day it was observed even in the morning.

After the long rainy period, the fine days with long sunshine, with high air temperature and with low humidity continued from July 24 to 28. But soil water

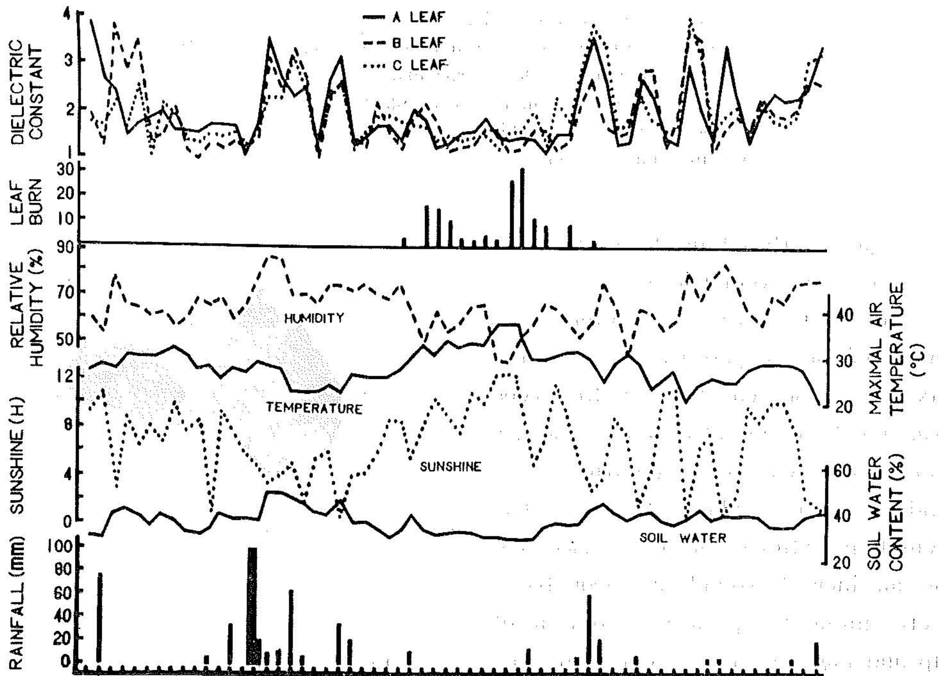

Fig. 5. Daily development of leaf burn by a change in weather conditions. (July 1- August 31, 1971)

content did not decrease significantly. As leaf dielectric constant, a remarkable depression was commenced on July 24 and followed by the severe leaf burn outbreaking on July 29.

3. Diurnal change in leaf dielectric constant and meteorological elements

Five leaves of shoot bases in 'Bartlett' trees and 2 leaves for 'La France' trees were chosen, and their dielectric constants were measured at interval of an hour from 6 a.m. to 8 p.m. on July 7 to 10 and on August 11, 1971. Typical patterns of diurnal change in dielectric constant of pear leaf with change in meteorological elements are indicated in Fig. 6.

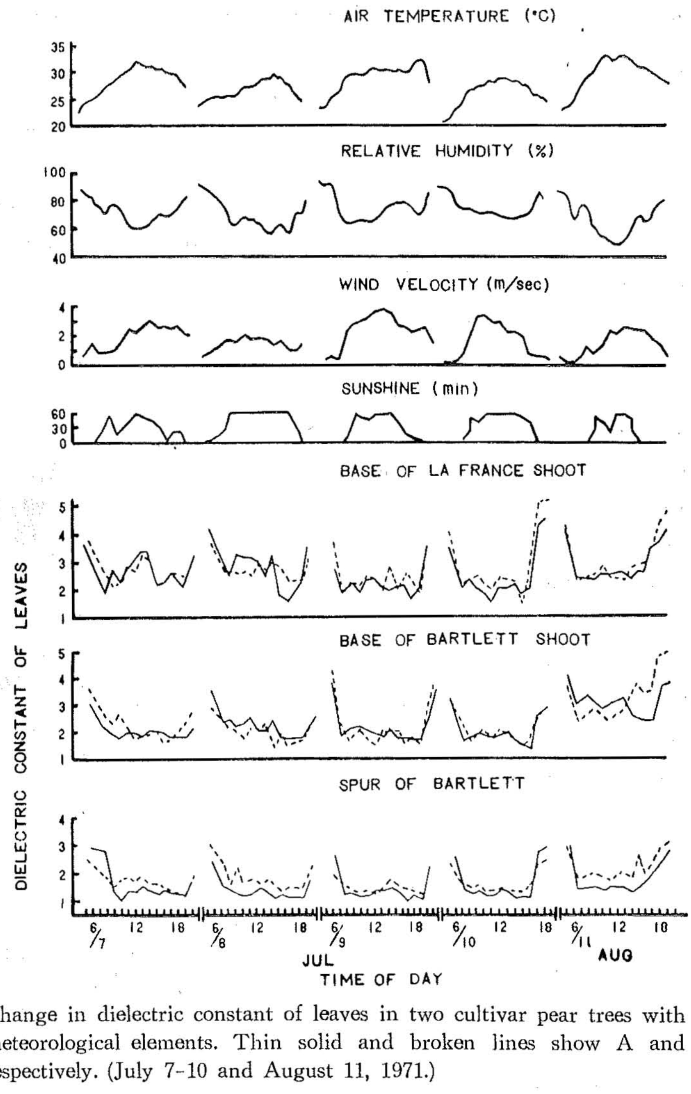

Fig. 6. Change in dielectric constant of leaves in two cultivar pear trees with change in meteorological elements. Thin solid and broken lines show A and B leaves, respectively. (July 7-10 and August 11, 1971.)

Rapidly decreasing from 8 a. m. to 10 a. m., usually, leaf water content rapidly increased at about 6 p. m.. It is noticeable that leaf water content of 'La France' shoots increased considerably near noon, while those of shoot bases and spurs in 'Bartlett' trees did not increase so great as that of 'La France'. This is obvious on July 7 and 8. But in the day transpired extremely, July 9 and 8, an increase near noon did not occur even in 'La France' trees. On August 11, in spite of high temperature, of high wind velocity and of low humidity the increase in leaf water content did not recover in the daytime even in 'La France'. Owing to the short sunshine time leaf water content was comparatively higher in that day than in the other 4 days. Hence, water deficits of pear leaves were strongly dependent on sunshine times among meteorological elements during measurement.

4. Observation leaves and change in dielectric constant during development of leaf burn

When observed an advance of leaf burn, the advance is considered to divide into 3 stage. At first, in the first stage some areas of the adaxial side of the leaf changed from deep green into lusterless and light-yellowish green, and their abaxial side was dull light green. Next, in the second stage as shown in Fig. 7, in the yellowish green area of the adaxial side dark brown or black polygonal speckles appeared scatteringly near the healthy area, then these speckles increased reticulately over all the injured area. At last, in the third stage all the surface of injured area changed almost black and the similar symptom extended from the adaxial side to the abaxial side.

Dielectric constant is shown in Table 1 according to such three stages. Dielectric constant strikingly decreased with advance of symptom of leaf burn, but in healthy area it decreased or increased slightly at afternoon. A remarkable dehydration occurs in pear leaves before development of leaf burn.

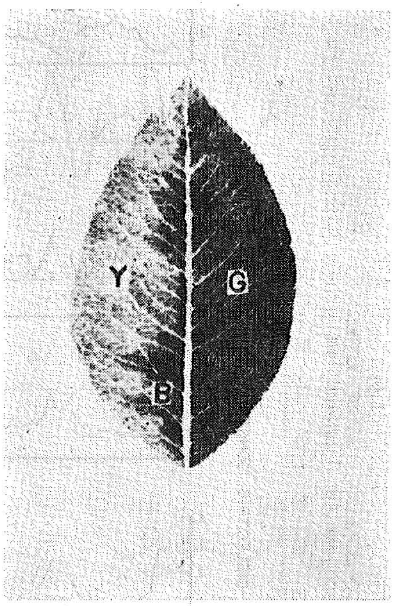

Fig. 7. Change in leaf colour with developing of leaf burn (adaxial side).
G. Healthy area (deep green)
Y. Dehydrated area (light yellowish green)
B. Dark brown or black polygonal speckles

5. Development of leaf burn in rainy season

A change in environmental conditions brought about leaf burn in rainy season in 1972. It is shown in Fig. 8.

Table 1. Change in dielectric constant of pear leaves when leaf burn is occurring. (August 10, 1971)

		Stage I	Stage II	Stage III
Symptom area	A leaf	1.75 (13 : 26)	1.18 (14 : 27)	1.10 (15 : 30)
	B leaf	1.90 (11 : 03)	1.30 (11 : 54)	1.25 (13 : 45)
	C leaf	2.55 (10 : 45)	1.85 (11 : 48)	1.35 (13 : 30)
Healthy area	A leaf	2.45 (13 : 25)	2.35 (14 : 27)	2.20 (15 : 30)
	B leaf	3.05 (11 : 02)	2.30 (11 : 45)	2.80 (13 : 30)
	C leaf	2.95 (10 : 43)	3.00 (11 : 48)	2.80 (13 : 31)

Stage I Normal green area of pear leaves turns yellowish green.
Stage II Adaxial side of the leaves in the stage I turns black.
Stage III Black colour extends to abaxial side.
( ) indicates the time of a day.

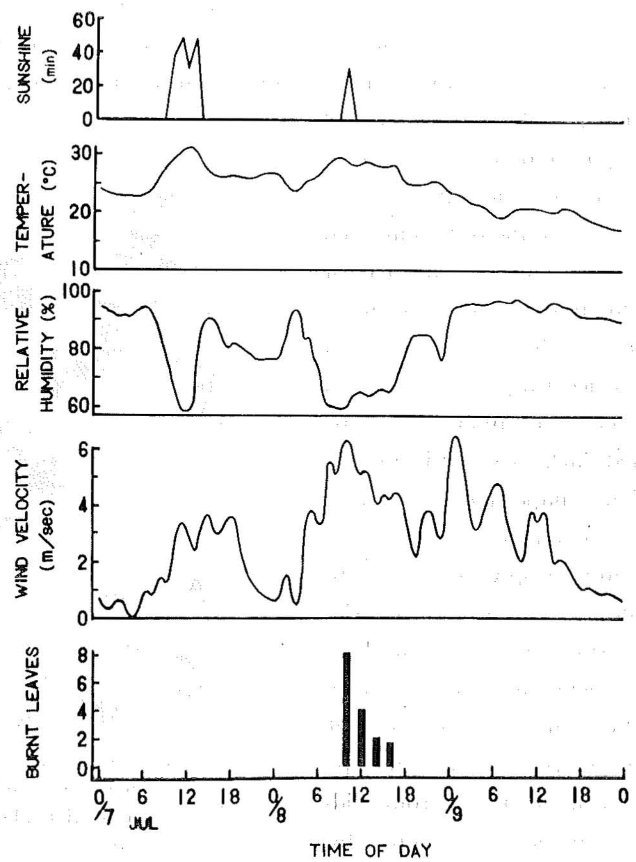

Fig. 8. Development of leaf burn brought on by the strong wind in rainy season. (July 7-9. 1972.)

Soil moisture tension was about 40 mm Hg (pF=1.73) with tensiometer for three days, while it was about 250 mm Hg (pF=2.51) in successive fine days. In spite of an excess of soil moisture, of lower temperature and of shorter sunshine, leaf burn suddenly occurred in the morning on July 8. Thus, it seems that leaf burn occurred by the strong wind since the early morning and thereby the rapid decrease in air humidity.

Disucussion

Dielectric constant of intact leaves strikingly decreased with advance of symptom of leaf burn. And these finding proved the view which was suggested by authors from the results of previous experiments using detached leaves (1972 b).

It seems that the patterns of leaf burn symptom associate with the developing process of leaf water deficits. Namely it seems that symptom of leaf burn appears and spreads out in the areas with less resistant tissues to leaf water deficit. SLATYER (1967) desciribed that the degree of leaf water deficits, that is, the quantitative lag of total absorption behind total transpiration, relates with weather conditions, with amount of soil water and with physiological function of both conductive tissues and transpirative tissues in leaves. These factors mentioned above will bring out various patterns of symptom of leaf burn. Therefore it is difficult to observe how each pattern develops. In desiccating the detached leaves in previous experiments (1972 b), the leaves turned dark brown within several hours, and its shape and its location were similar to anyone of all types in Fig. 3. When water supply of shoots to leaves was decreased, symptom of the tip and margin types occurred in 'Bartlett' leaves on shoot bases after 3 days from the treatment. It is considered that water supply is restricted at leaf tips and margins to be far distance from midveins. Such a phenomenon is noted by TRESHOW (1970). For water supply of veinlets to mesophyll cells, WYLIE (1939) found that mean distance between the

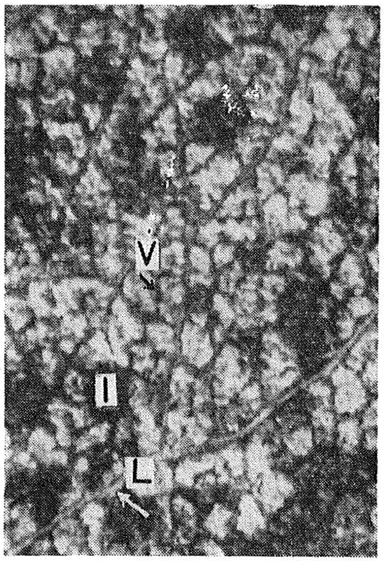

Fig. 9. Turning black of polygonal shape enclosed by veinlets in abaxial side of a 'Bartlett' leaf.
I. Injured area
L. Lateral vein
V. Veinlet

minor veins of 66 species is about 130 microns, which is twice the conduction distance in the midplane. There is a difference in the distance between not only minor veins but also the first or secondary lateral veins. Further, there is a difference in a number of stomata left to open between small areas enclosed by veinlets (Fig. 9.). If water content of leaves reaches to a limit for developing leaf burn and transpiration still overrides water supply to leaves, some parts between lateral veins or veinlets in a leaf will become leaf burn or the other parts will not.

It is necessary for prevention to find which meteorological element influences most strongly upon leaf burn. On August 5 to 6, 1971 and July 8, 1972, strong wind continued to blow all the day. Further, it was very fine on August 5 and 6. Leaf burn might be resulted from wind and sunshine. Usually in the nighttime a leaf regains water lost by transpiration in the daytime as seen in Fig. 6, but can not regain water by strong wind of all night. Especially, on July 8, leaf burn may severely occur by strong wind from midnight to midday, though cloudy day. Soil moisture as an environmental factor may not influence upon leaf burn so far as it may not extremely decrease.

Leaf water content directly influences upon leaf burn. The leaf water content strikingly decreases for several successive fine days because transpiration overrides water supply. Such a phenomenon was found by IIZUKA (1967). The leaf water content of shoot bases increased near noon during a decrease in the 'La France' tree, but did not increase in the 'Bartlett' tree. This is due to have lost stomatal function in 'Bartlett' leaves. Occasionally leaf burn must be caused by such facts.

After all, strong wind continues to blow from midnight to midday without rain, in this case, leaf burn severely occurs, especially it occurs in the leaves of a spur and shoot base of 'Bartlett' trees because to have lost stomatal function. Whereas from organization of veins, the leaf burn may occur owing to the difference in the distance between lateral vains or veinlets or may not, which play the part of water supply. Such a phenomenon seems to bring out various patterns of symtom.

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Summary

In this paper the investigations on relations between leaf burn and meteorological elements, soil water content and leaf water content were conducted by finding dielectric constant of leaves as water content. Besides patterns of symtom of leaf burn were described.

The symptom of leaf burn were classified into 6 patterns according to location and size, namely, an entire leaf turns black, one side of a leaf separated by a midvein turns black, a patch within a leaf turns black, a leaf tip and a margin turn black, scatterrd black speckles and interveinal lesion. The symptom of leaf desiccation by wound at a shoot base of 'Bartlett' trees were similar in appearance to that of leaf tip and margin in actual leaf burn.

It may be found that wind and sunlight among meteorological elements effect more strongly on leaf burn. Especially it is pronounced that when strong wind continues to blow all night without rain leaf burn occurs on the following day by short sunshine times even in rainy season.

Leaf water content in pear trees decreased rapidly about 8 a. m. and increased at 6 p. m. on fine day usually, but leaf water content increased near noon in 'La France' shoot base, while leaf water content in a 'Bartlett' shoot and spur did not increase so great as that in 'La France' trees.

From these observations on the extreme decrease in leaf dielectric constant and on the feature of leaf colour change, it is evident that leaf water content decreased extremely when leaf burn was about to occur.

摘　　要

西洋ナシの葉やけに関する研究（第5報）
葉水分と気象条件

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蒸散に対して大きな影響を有する葉の気孔の開閉機能の異常が，西洋ナシの葉やけの内的原因であることはすでに報告された．その外的条件となる，蒸散を促進する気象条件について調査する必要がある．本報告では，葉やけと気象要素，土壌水分，葉水分との関係，ならびに葉やけ症状の型が詳細に調査された．葉水分の表示に葉の誘電率がもちいられた．

葉やけ症状の型はその大きさや形から次の6型に分類された．すなわち，葉全体にひろがるもの，中央脈をさかいとして片側全体にひろがるもの，大きな斑状のもの，葉の先端だけにみられるもの，小斑で分散しているもの，葉の側脈でかこまれているものなどである．新梢の基部を傷つけて葉やけ類似症状を発生させたが，この人工的な葉やけは，実際に発生する葉やけ症状の型のうち，葉の先端や葉縁に発生するものにのみ酷似した．

雨期又は雨期後の観察の結果，西洋ナシの葉水分不足に対する抵抗性は大気の低湿度の持続期間により異なるものと思われた．

気象要素は互いに影響しあうので，どの気象要素が葉やけ発生に最も作用するのか判断し難い．とりわけ，いうならば雨期においては，夜間風が吹きつづけたとき，翌朝の短時間の日光の照射で葉やけが発生するのがみられた．葉やけは，水分不足になれている葉よりも，なれていない葉に生じやすいものと考えられた．

西洋ナシの葉水分は通常午前8時頃急速に低下し，午後6時頃上昇する．ラ・フランスの新梢基部の葉水分は，真昼に一時上昇するが，バートレットの新梢基部葉と短枝葉とでは，葉水分はほとんど上昇しなかった．

葉の誘電率の著しい低下と葉色変化との観察から，葉やけが発生しはじめる時，葉水分が著しく低下することがあきらかになった．